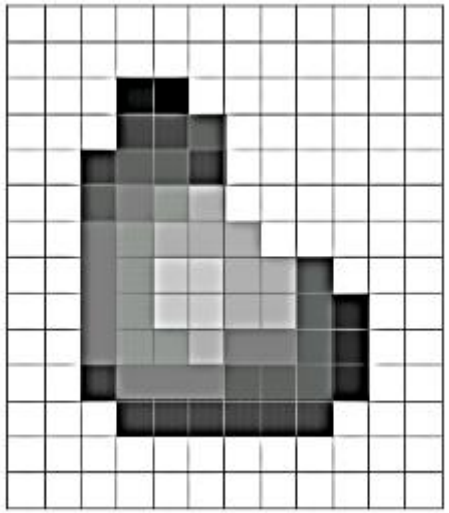
Computer Vision

Section 1

Images

- Image is a grid (matrix) of intensity values: 1 color or 3 colors
  - Black and white (0 or 1 for 1-bit images)
  - Grayscale (0–255 for 8-bit images)
  - Color images (Three channels (Red, Green, Blue))

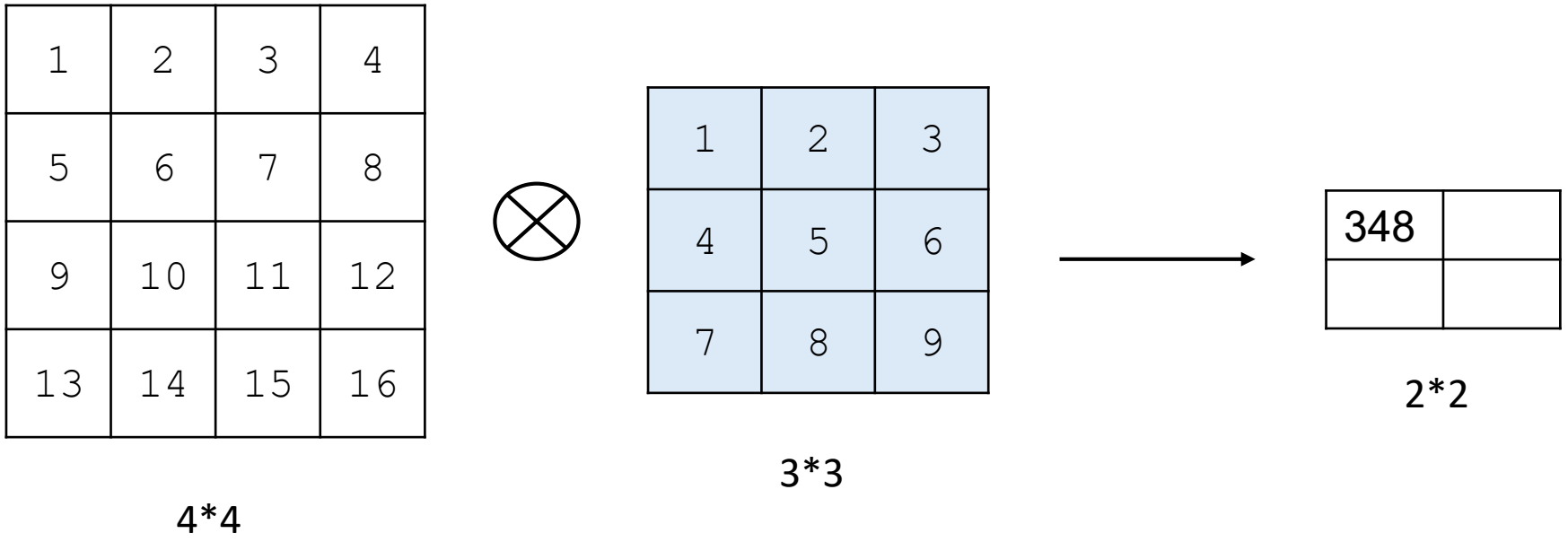
Grayscale



255	255	255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255	255	255
255	255	255	20	0	255	255	255	255	255	255	255
255	255	255	75	75	75	255	255	255	255	255	255
255	255	75	95	95	75	255	255	255	255	255	255
255	255	96	127	145	175	255	255	255	255	255	255
255	255	127	145	175	175	175	255	255	255	255	255
255	255	127	145	200	200	175	175	95	255	255	255
255	255	127	145	200	200	175	175	95	47	255	255
255	255	127	145	145	175	127	127	95	47	255	255
255	255	74	127	127	127	95	95	95	47	255	255
255	255	255	74	74	74	74	74	74	255	255	255
255	255	255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255	255	255

Cross-correlation

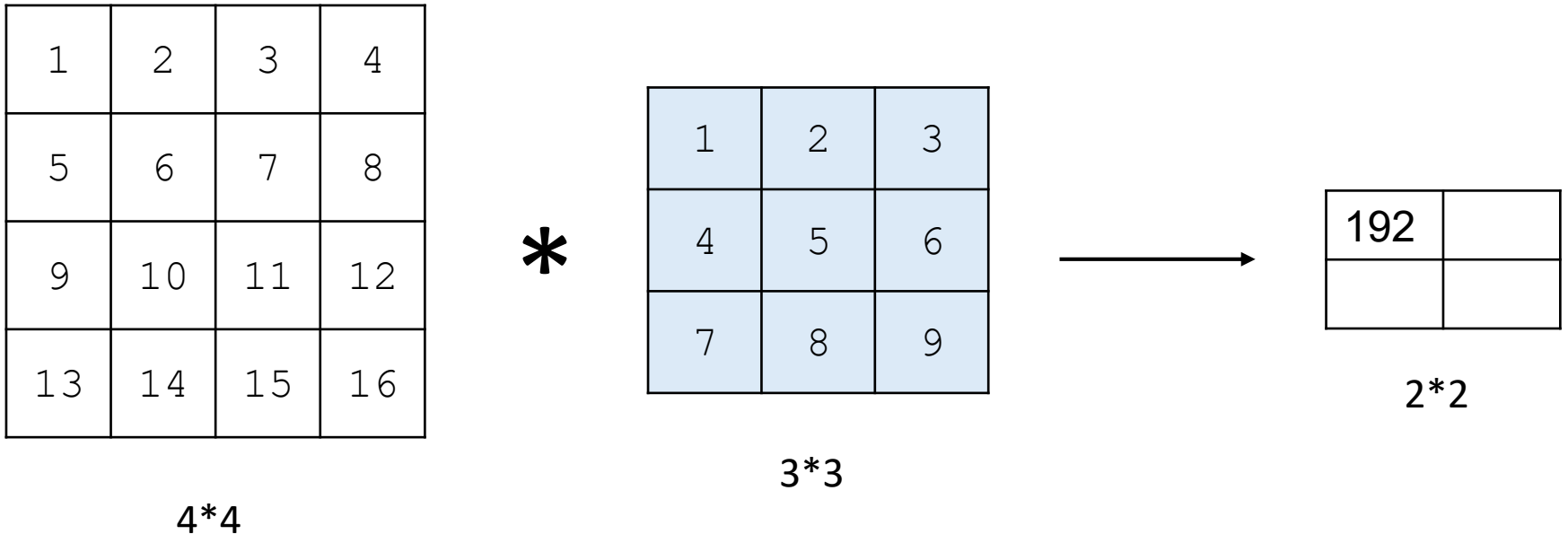
Cross-correlation is a mathematical operation used to measure the similarity between two signals or images.



1*1+2*2+3*3+4*5+5*6+6*7+7*9+8*10+9*11 = 348

Convolution

Convolution is a fundamental mathematical operation in image processing used for filtering.



9*1+8*2+7*3+6*5+5*6+4*7+3*9+2*10+1*11 = **192**

Images filtering

- Filtering is a technique used to modify or enhance an image by applying mathematical operations to pixel values.
- It is widely used for:
  - Noise reduction
  - Edge detection
  - image sharpening
  - feature extraction
- **Spatial Filtering**
  - In spatial filtering, operations are performed directly on the pixel values of the image.

Images filtering

- **Linear Filtering**
  - Linear filters apply a convolution operation between an image and a filter (kernel/mask).
    - **Smoothing Filters (Low-pass filters)** – Used to remove noise and blur images.
    - **Sharpening Filters (High-pass filters)** – Used to enhance edges and details.
- **Non-Linear Filtering**
  - These filters do not use convolution but apply other mathematical operations.
    - **Median Filter**
    - **Mean Filter**

Apply 3*3 Low-Pass Filter

Fuzzy or Blurred

150	150	150	150	150
150	150	150	150	150
150	150	150	150	150
150	150	150	150	150
125	125	125	125	125
25	25	25	25	25
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

Smoothing Edges

$$1/6 * \begin{matrix} 0 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 0 \end{matrix}$$

100	100	100	100	100
50	50	50	50	50
100	100	100	100	100
50	50	50	50	50
100	100	100	100	100
50	50	50	50	50
100	100	100	100	100
50	50	50	50	50
100	100	100	100	100
50	50	50	50	50

dimmer or washed

Apply 3*3 Low-Pass Filter

Apply 3*3 high-Pass Filter

150	150	150	150	150
150	150	150	150	150
150	150	150	150	150
150	150	150	150	150
255	255	255	255	255
0	0	0	0	0
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

Amplified the edge

Enhancing Edges

0	-1	0
-1	5	-1
0	-1	0

255	255	255	255	255
0	0	0	0	0
255	255	255	255	255
0	0	0	0	0
255	255	255	255	255
0	0	0	0	0
255	255	255	255	255
0	0	0	0	0
255	255	255	255	255
0	0	0	0	0

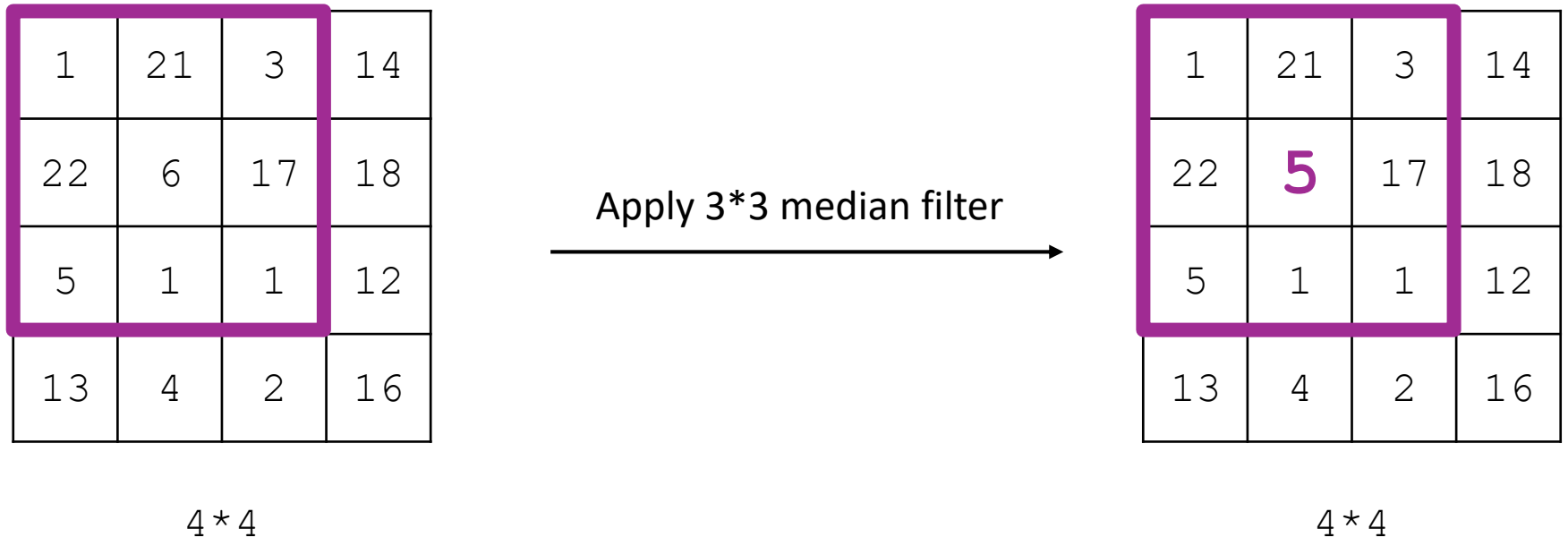
amplified many edges

Apply 3*3 high-Pass Filter

Median Filter

- A special type of low-pass filter, the median filter, replaces the center pixel with the median of the surrounding pixels.
- This is effective for noise reduction while preserving edges, as it does not average pixel values but selects the median.
- Median Filter is used to:
  - Smooth out sharp transitions in gray levels.
  - Remove noise from images.
- Median Filters use convolution masks (e.g., 3x3 or 5x5) to determine how pixel values are averaged. The center pixel is typically replaced by the average value of its neighboring pixels, resulting in a smoother image.

Median Filter

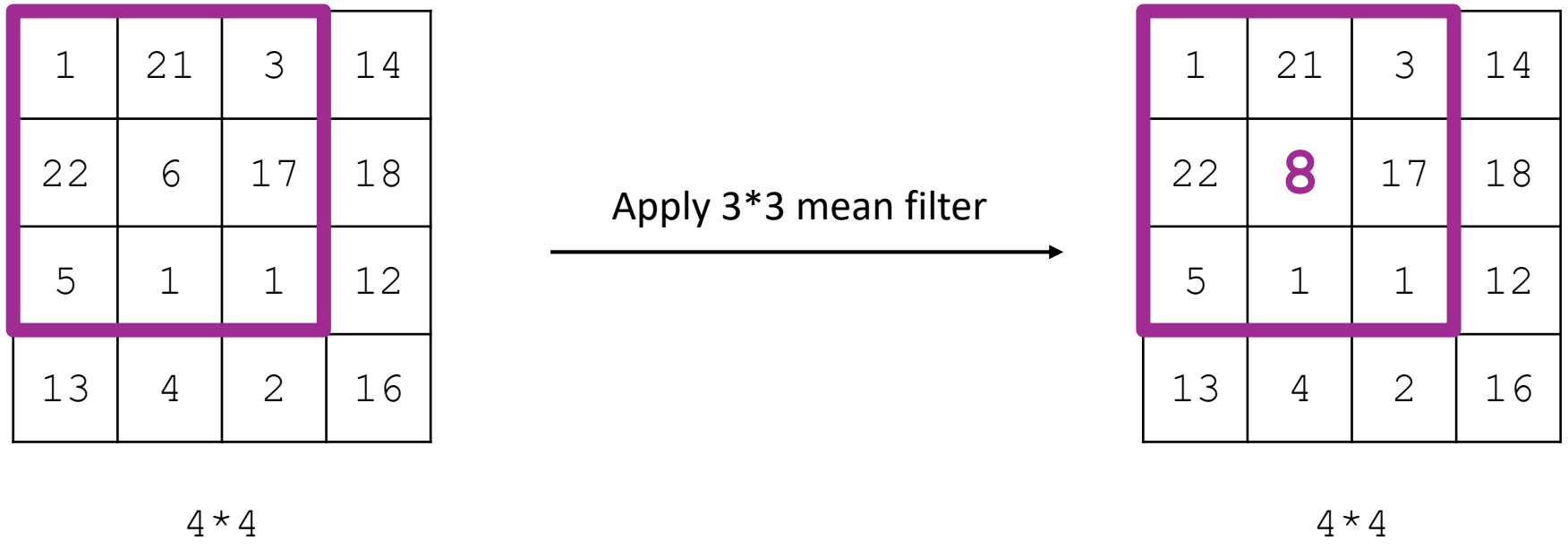


4*4

4*4

Median Filter

Mean Filter

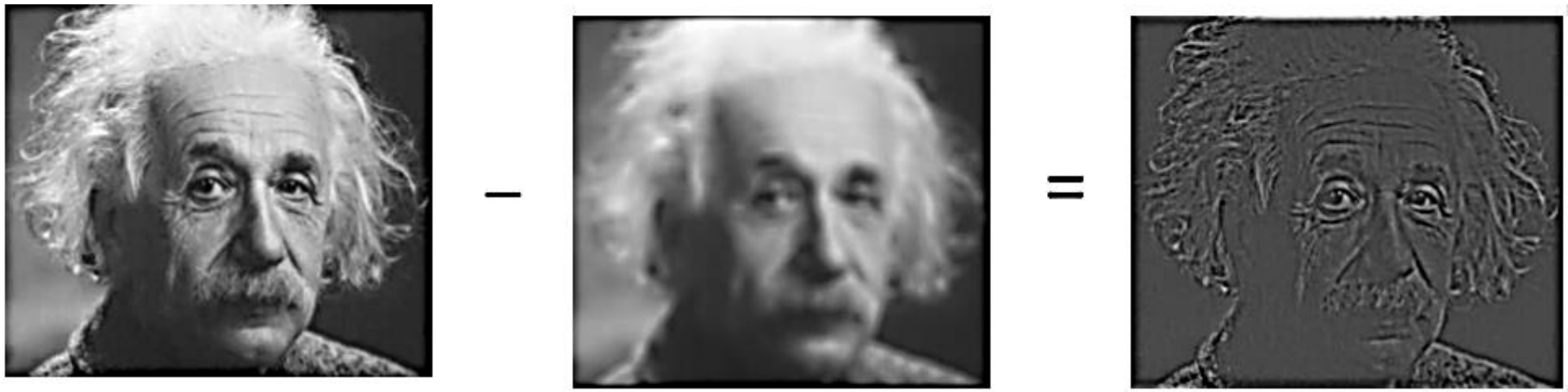


4*4

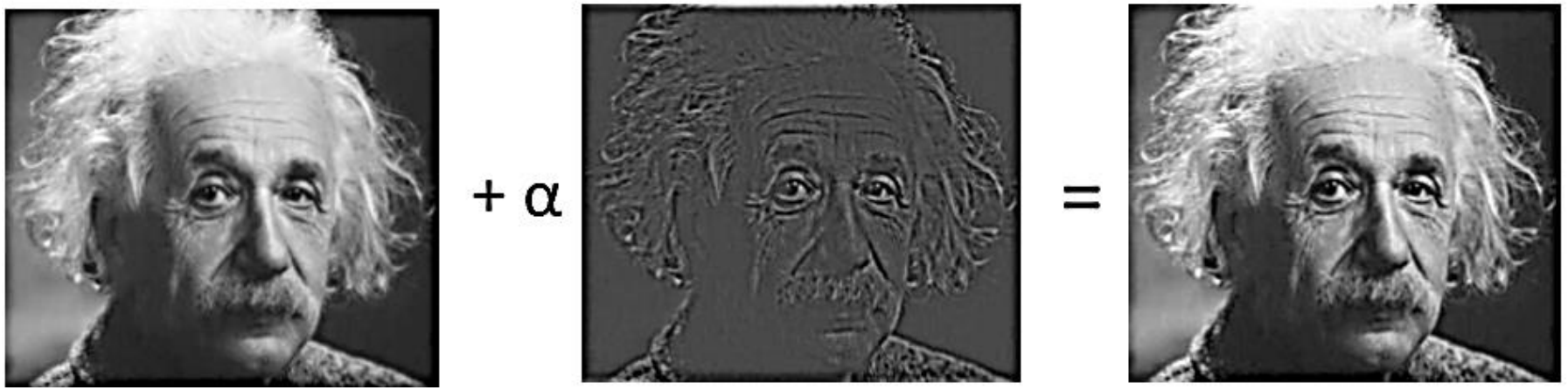
4*4

(1+21+3+22+6+17+5+1+1)/9 = 8

Sharpening using low pass filters



Let's add it back:



Thanks